Technology Program Management Model (TPMM) Executive Overview

A Systems-Engineering Approach to Technology Development and Program Management

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Introduction

TPMM V2 applies a **systems engineering methodology** to Technology Program Management

This presentation will provide a high-level overview of how a model like the TPMM can provide the Defense S&T community as a whole with the following benefits:

- **Re-Introduces Systems Engineer**
- **Facilitates Stakeholder Alignmer**
- **Better Insight into Program Exec**
- **Reliable Management Decisions**
- **Improves Technology Transition**

Challenge of Every S&T and Acquisition Organization

Effectively ***managing technology development***

- Programmatic problems
- Lack of Systems Engineering Principles

Successfully ***transitioning technologies***

- Transition not considered as part of Tech Dev
- Lack of Customer/User identification/involvement

Quantifying the Effects of Immature Technologies

According to a GAO review in 2005 of 54 DoD programs:

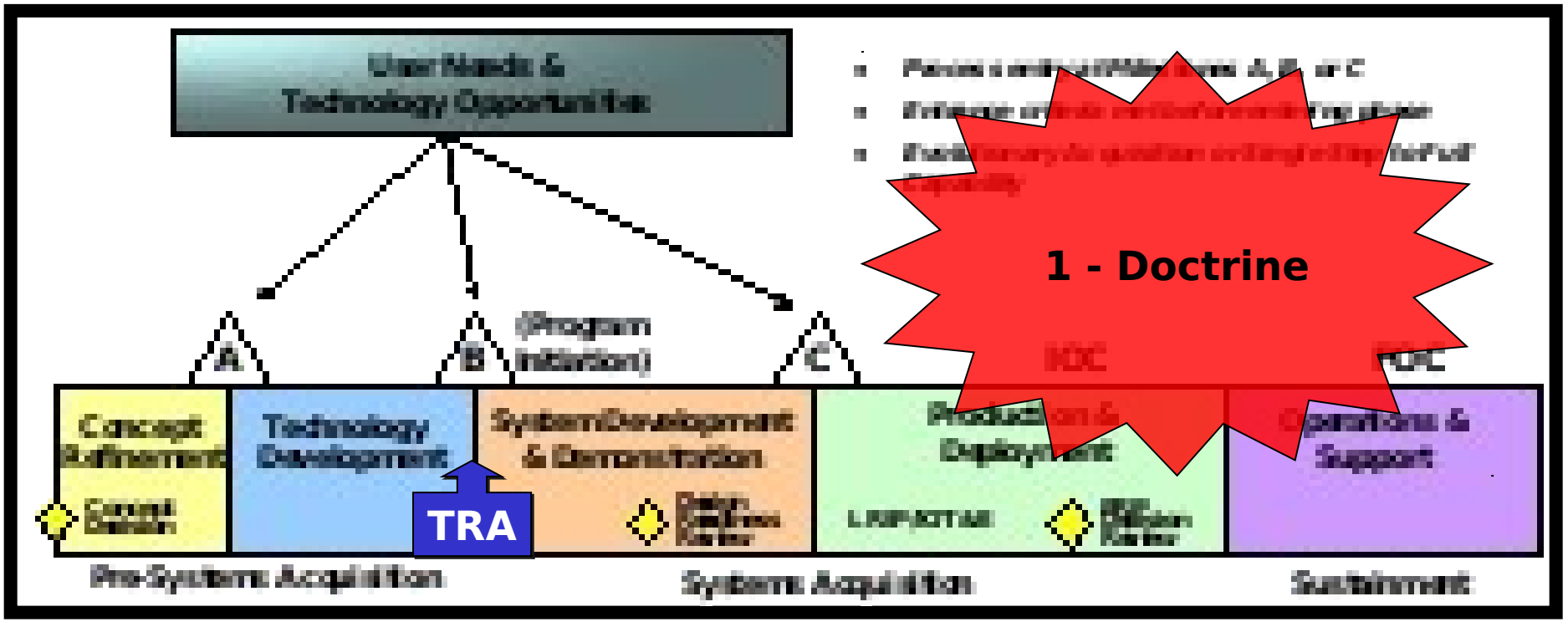
- Only 15% of programs began System Design Decision [post MS B] with mature technology (TRL 7)
  - Programs that ***attempted to integrate with immature technologies*** averaged ***41% cost growth*** and a ***13 month schedule delay***
- At Critical Design Review, 58% of programs demonstrated design instability (< 90% drawings releasable)
  - ***Design stability not achievable with immature technologies***
  - Programs ***without stable designs at CDR*** averaged ***46% cost growth*** and a ***29 month schedule delay***

5 Reasons Why This Happens

- ***Doctrine*** Promotes delay
  - The DoD 5000 doesn't call for the first Assessment of the technology until MS-B (too late in the process to have any real effect on an immature technology)
- ***Predisposition*** of Viewpoints
  - Users know the requirements, Acquisition Managers know how to build things, and Technology Developers know how to invent.
  - A Forcing Function is needed to effectively cross those boundaries
- ***Communication*** Breakdown
  - Tech solutions selected to fill gaps need continual re-alignment to ensure development is on schedule and that the "right" problem is still being solved
- ***Culture*** Within the Technology Development Community
  - Tradition of Invention and scientific endeavor in the Technology Community contributes to a lack of Transition Focus
- ***Interpretation*** Wide Enough to Drive a Humvee Through
  - TRL definitions are vague and sometimes too subjective which can lead to more questions than answers.

A System Engineering and Programmatic-based TRL criteria set needs to be applied as a standard *earlier* in the process

First TRA Requirement



DoD 5000 Metric

echnology Readiness Assessment (TRAs) - Required at MS

- **TRAs using Technology Readiness Levels (TRLs)**

Perspectives

Hey Buddy - I OWN The Requirements !

Gotta be small, lightweight, and 99.99% reliable

I Want it All!! I Want it Cheap! I Want it Now!

I'm governed by the JCIDS

- Threat Driven
- Soldier-Proof
- Fieldable
- Meets Mission Needs
- **DOTMLPF**

USER

Your next chance for funding is 5 years down the road – stud!

I NEED a REQUIREMENT (CDD)!

My prime can do that!!

I am governed by DoD 5000.

You forgot about the "illities"!!!

2 - Predisposition

- Value Added
- Capability
- Probability of Success
- Acquisition Strategy
- Budget (LLC/POM)
- Schedule - WBS
- The System " approach"

PM

If you "Push" long enough – they will come!

You don't understand - This project is different from everyone else

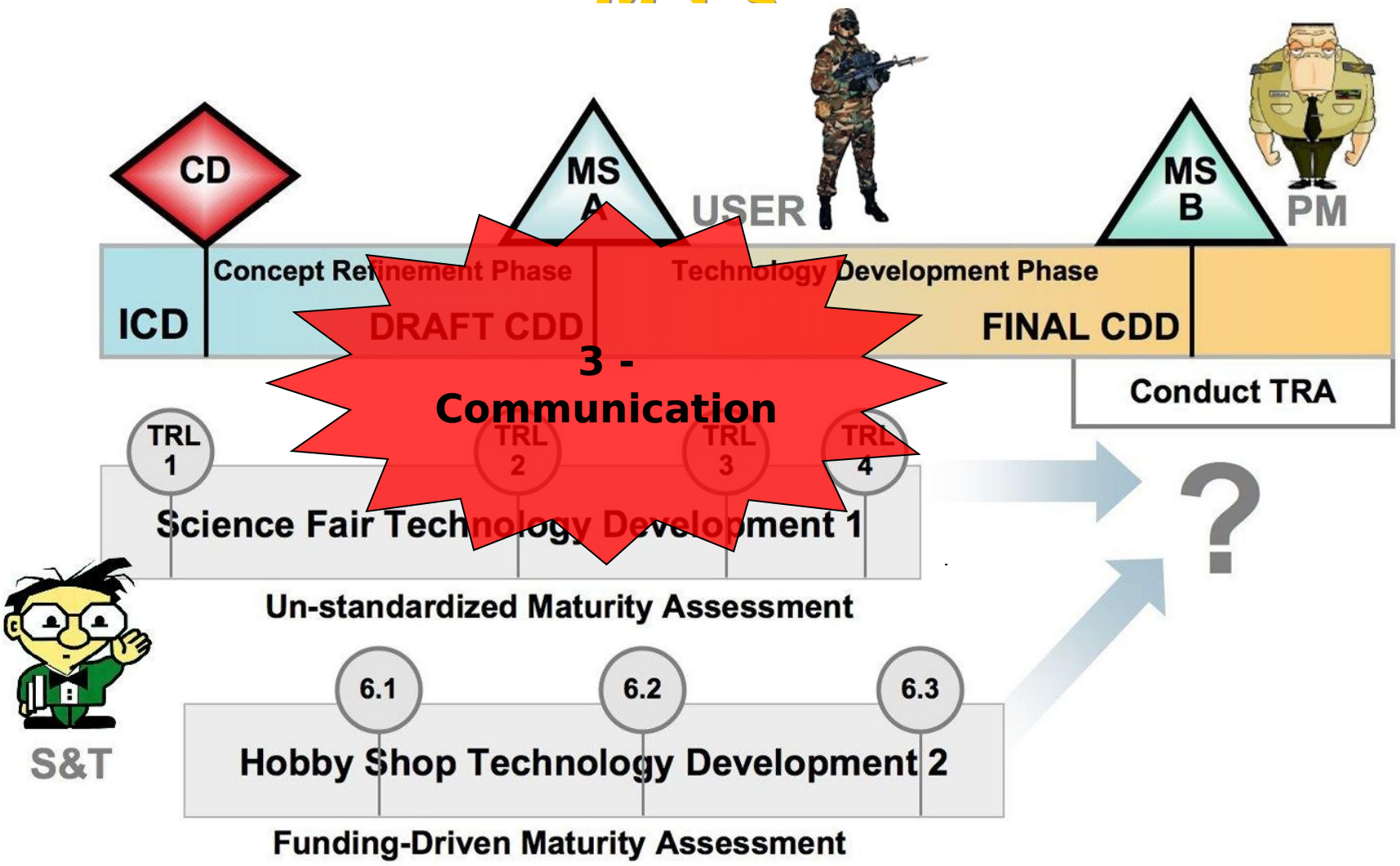
S&T does not require a process – I have been doing it for years

Customer role is to integrate

- Technical "break-thru
- Performance Goals
- Risk
- Cost Estimate.
- Program Plan
- Build a prototype

S&T

Aligning Technology with the Acquisition DoD 5000 MS's



Transitioning Technology

Technology Management vs. Transition Management

Transition Management ➔

- Transition an afterthought
- Technologist still tinkering
- Not knowing when you're finished
- Not knowing when technology is needed

4 - Culture

Typical Paradigm

Technology Management ➔

Technology Readiness Levels

DoD 5000.2-R

1. Basic principles observed and reported.
2. Technology concept and/or application formulated.
3. Analytical and experimental critical function and/or characteristic proof of concept.
4. Component and/or breadboard validation in laboratory environment.
5. Component and/or breadboard validation in relevant environment.
6. System/subsystem model or prototype demonstration in a relevant environment.
7. System prototype demonstration in an operational environment.
8. Actual system completed and qualified through test and demonstration.
9. Actual system proven through successful mission operations.

Lowest level of technology research begins to be translated into technology's basic properties.

Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.

Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.

Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.

Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.

Representative model or prototype system, which is well beyond that tested for level 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.

Prototype near or at planned operational system. Represents a major step up from level 6, requiring the demonstration of an actual system prototype in an operational environment such as in an aircraft, vehicle or space. Examples include testing the prototype on the targeted aircraft.

Technology has been proven to work in its final form and under expected conditions. In almost all cases, this level represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specs.

Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

5 - Subjective

In what way will this technology Add Value to the End User?

What Programmatic & System Engineering tasks should be performed during each Stage of Development?

When should I know who my Customer is?

When should I know what the requirements for the technology are?

At what point will the technology be transitioned to a Customer?

How will my progress be measured?

What are the criteria for completing a TRL?

What is the definition of a success?

Quantifying the Effects of Immature Technologies

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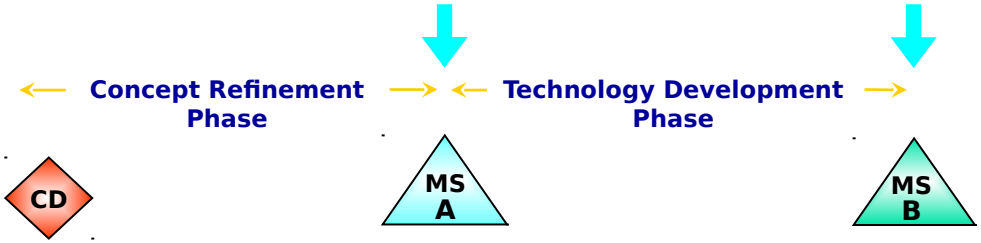
A System Engineering and Programmatic-based TRL criteria set needs to be applied as a standard *earlier* in the process.

Aligning TRLs & DoD 5000 Reduces Subjectivity



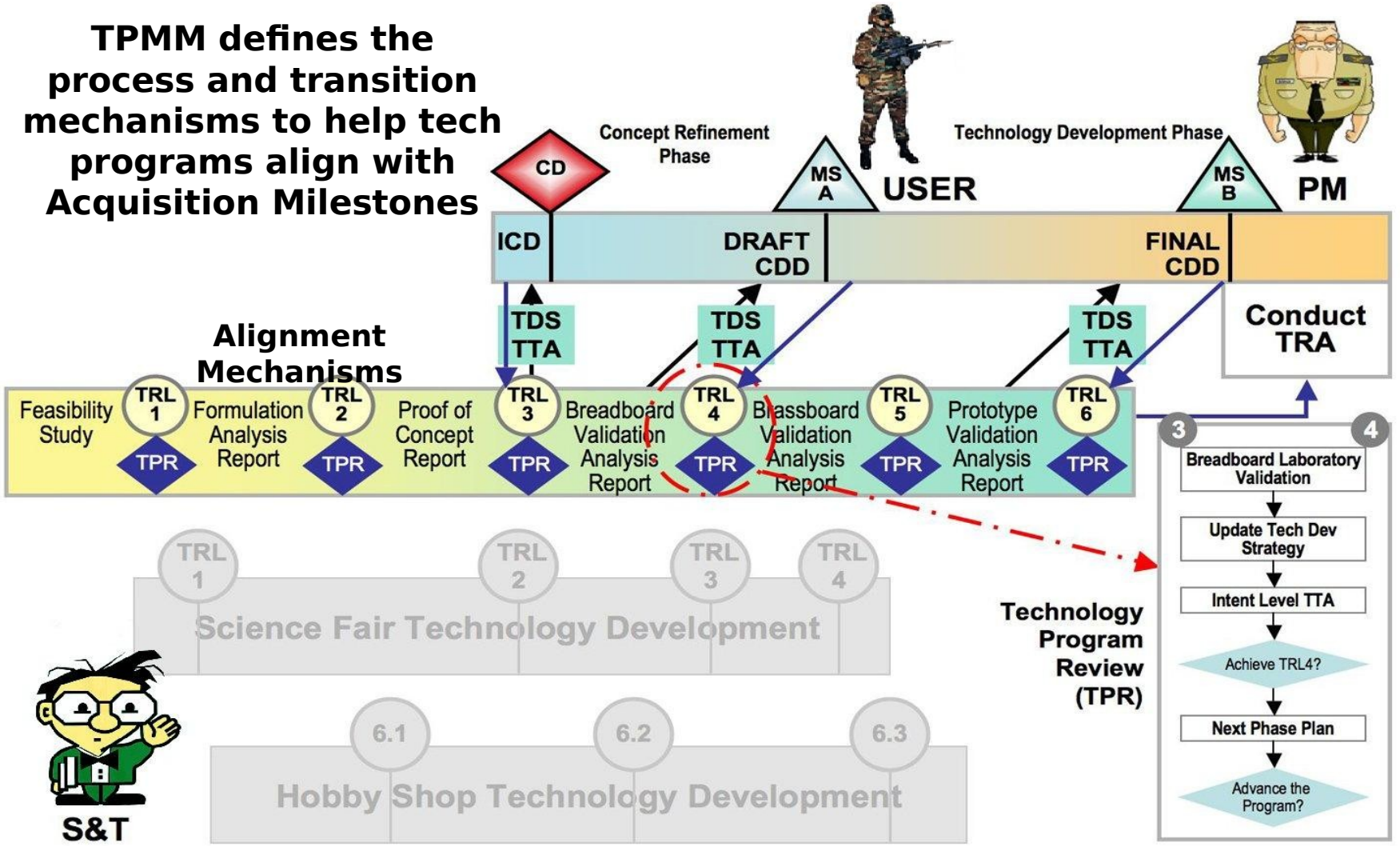
TPMM Criteria

TRL 1	TRL 2	TRL 3	TRL 4	TRL 5	TRL 6
1. Basic principles observed & reported	2. Technology concept and/or application formulated	3. Analytical and experimental critical function and/or characteristic proof of concept	4. Component and/or breadboard validation in laboratory environment	5. Component and/or breadboard validation in relevant environment	6. System/ subsystem model or prototype demonstration in relevant environment
Discovery	**Formulation**	**Proof of Concept**	**Refinement**	**Development**	**Demonstration Transition**
Develop an Idea Based on Threat, need, User Rqmt, Other Identify Pertinent Military Application & a Potential Customer(s)	Develop a Concept Conduct Trade Studies Perform Military Utility Analysis Perform Paper Studies Identify specific customer(s) Analysis of Alternatives	Proof of Concept and approach Develop General Technical Requirements ID cross technologies Develop Draft Tech Development Strategy ***TTA - Interest***	Demonstrate Key Technologies Work Together Refine Requirements System Eng Plan Update Tech Development Strategy ***TTA –Intent***	Demonstrate Components Work With/as System Finalize Requirements Develop Transition Plan and Gain Customer Approval	Demonstrate Prototype Ready for Operations Demonstrate Increased Capabilities Develop Transition Agreement Acquisition Strategy ***TTA – Commitment***

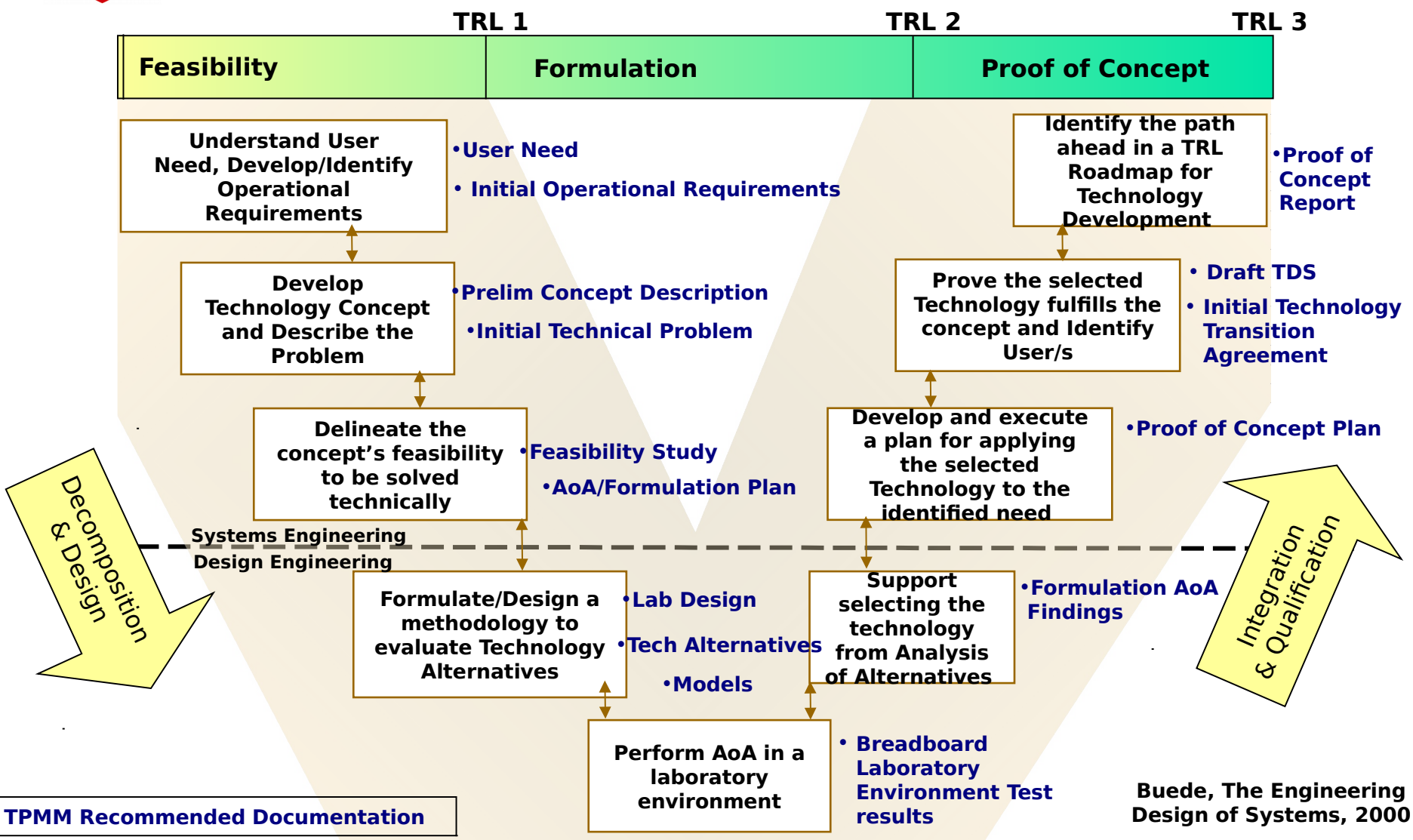
"Secure the High Ground"

Alignment Mechanisms Facilitate Effective Communication

TPMM defines the process and transition mechanisms to help tech programs align with Acquisition Milestones



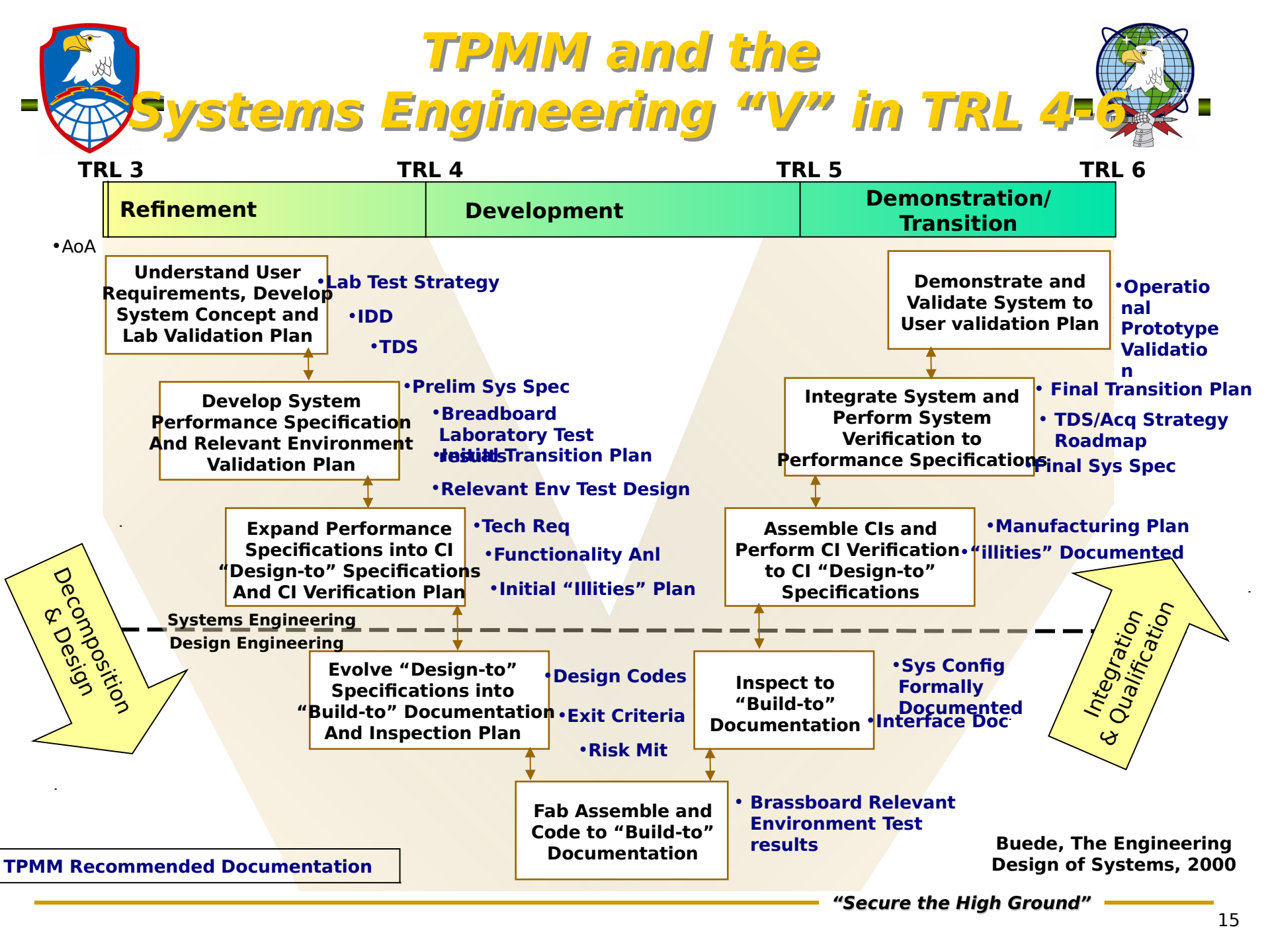
TPMM and the Systems Engineering "V" in TRL 1-3


TRL 1
TRL 2
TRL 3
Feasibility
Formulation
Proof of Concept
Understand User Need, Develop/Identify Operational Requirements
•User Need
• Initial Operational Requirements
Develop Technology Concept and Describe the Problem
•Prelim Concept Description
•Initial Technical Problem
Delineate the concept's feasibility to be solved technically
•Feasibility Study
•AoA/Formulation Plan
Systems Engineering
Design Engineering
Decomposition & Design
Formulate/Design a methodology to evaluate Technology Alternatives
•Lab Design
•Tech Alternatives
•Models
Perform AoA in a laboratory environment
• Breadboard Laboratory Environment Test results
Support selecting the technology from Analysis of Alternatives
•Formulation AoA Findings
Develop and execute a plan for applying the selected Technology to the identified need
•Proof of Concept Plan
Prove the selected Technology fulfills the concept and Identify User/s
• Draft TDS
• Initial Technology Transition Agreement
Identify the path ahead in a TRL Roadmap for Technology Development
•Proof of Concept Report
Integration & Qualification

TPMM Recommended Documentation

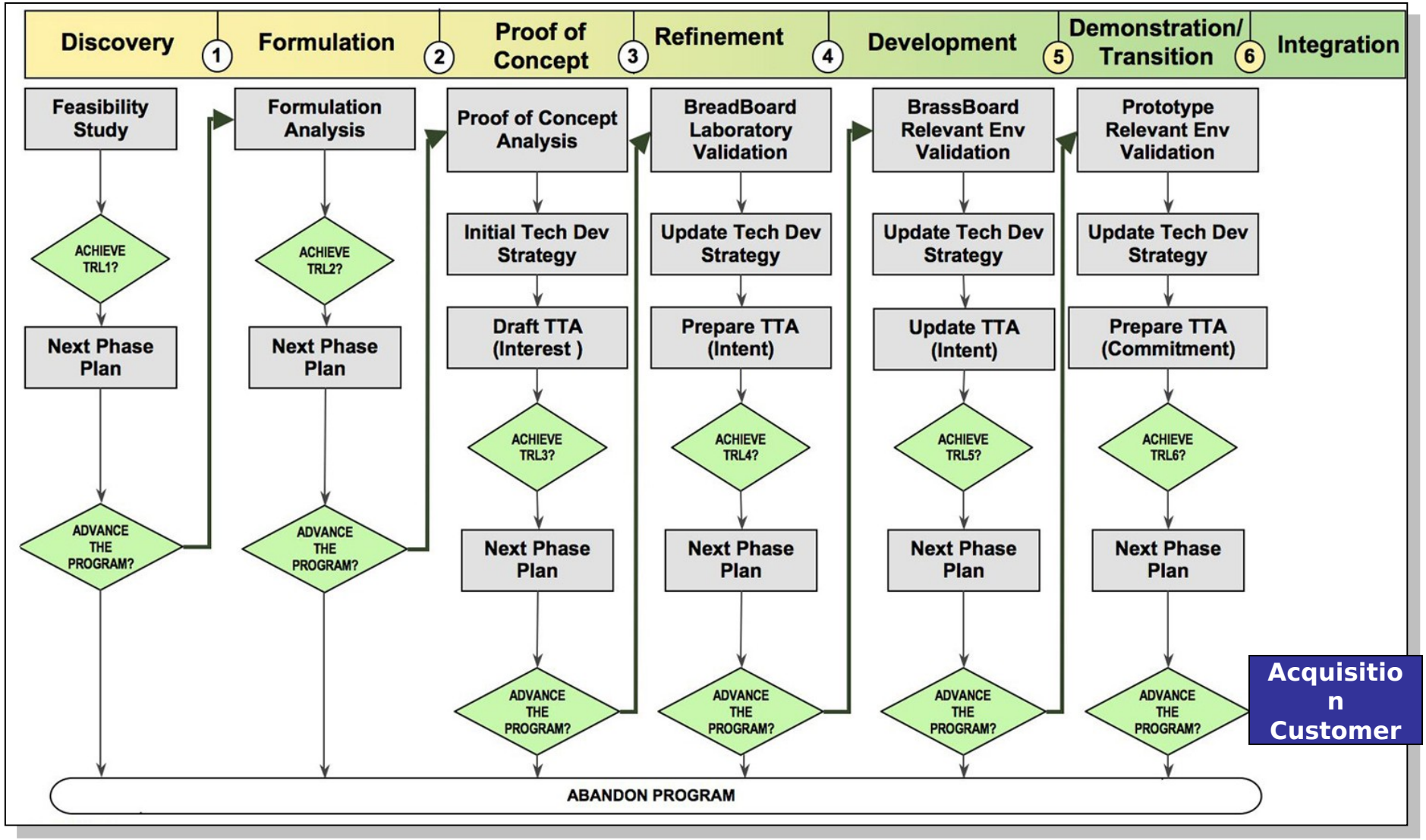
Buede, The Engineering Design of Systems, 2000

TPMM and the Systems Engineering "V" in TRL 4-6

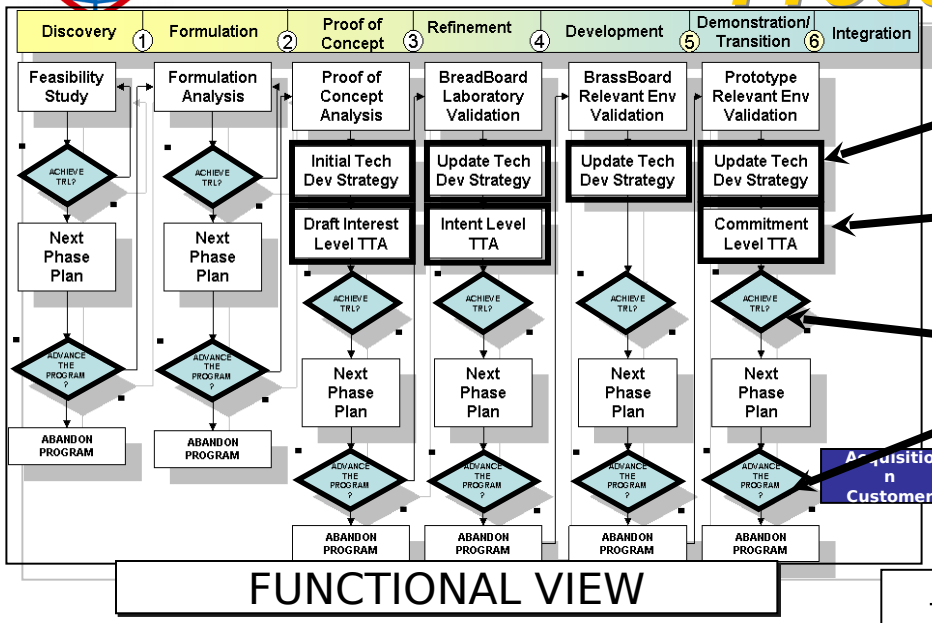


Buede, The Engineering Design of Systems, 2000

TPMM High-Level Process



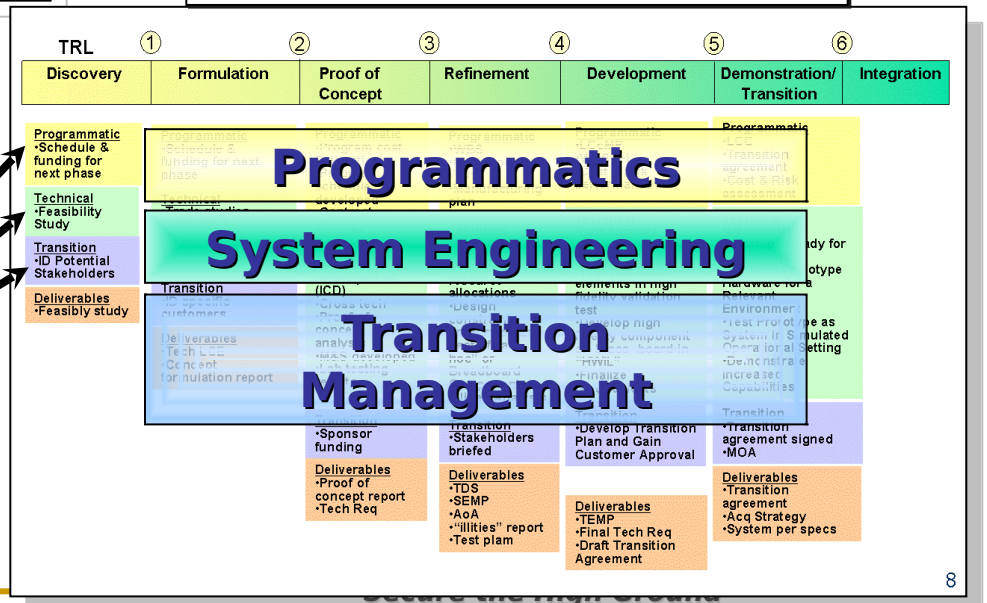
Systematic Development Methodology = Repeatable Process



FUNCTIONAL VIEW

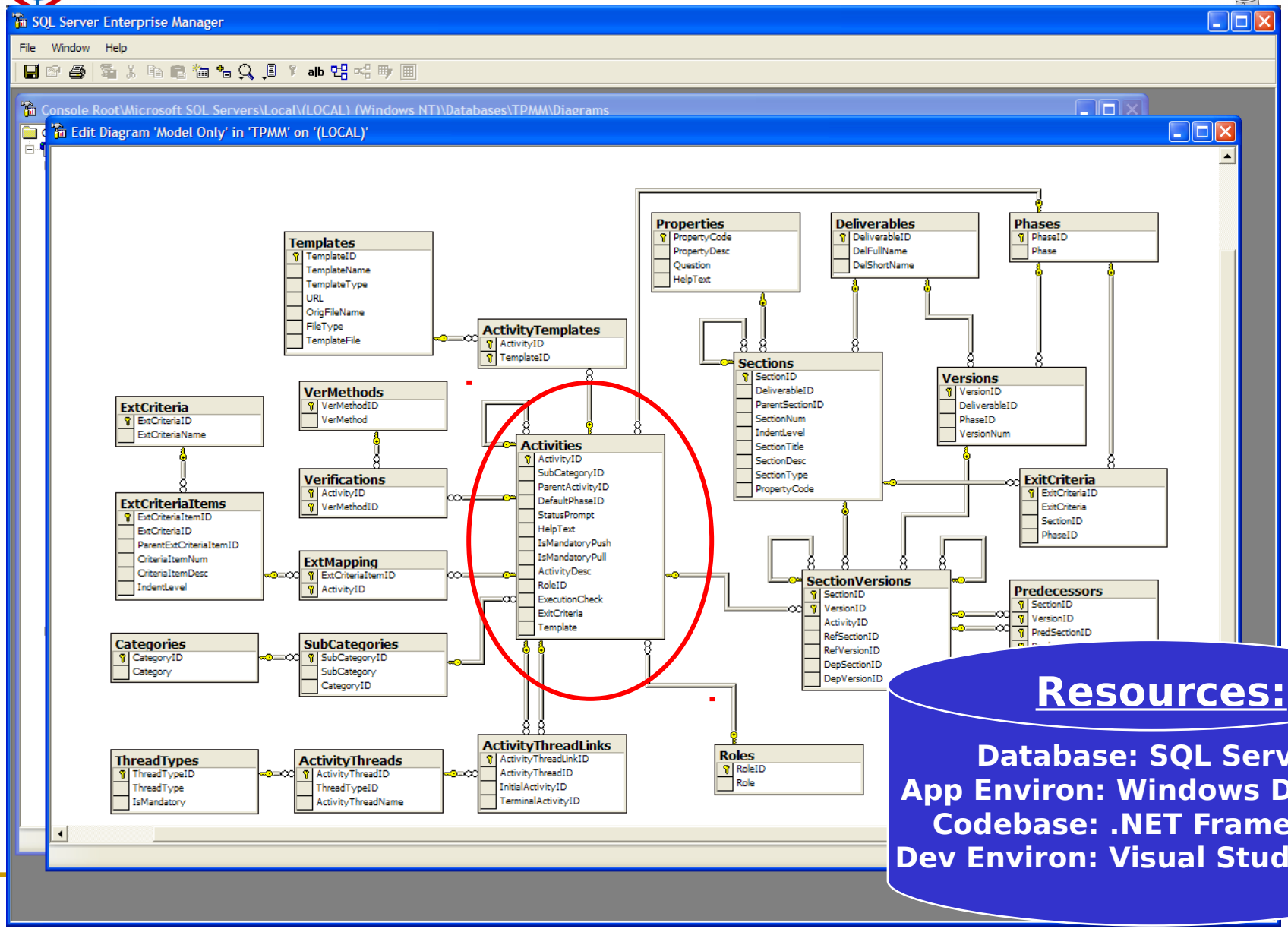
- TDS establishes common language and vision
- DAU adopted TTA
- Program reviews include a TRA and a TAA

ARCHITECTURAL VIEW



- Multi-Dimensional criteria set provides a comprehensive TRL Assessment

Physical View - Activity Centric Database



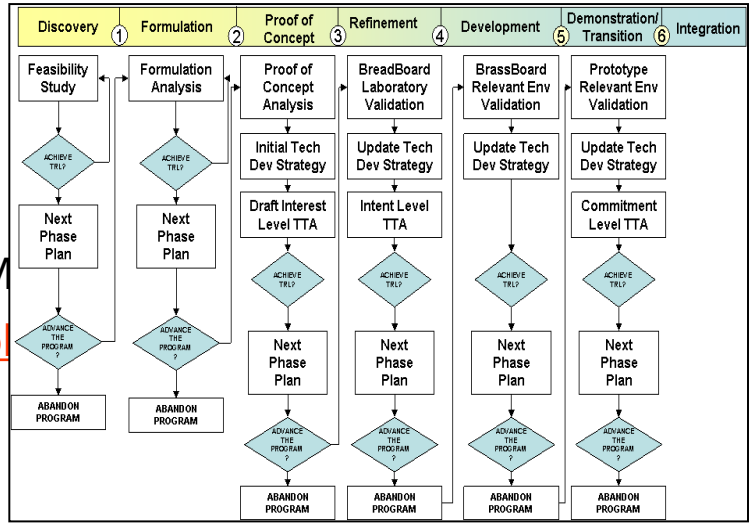
Resources:

Database: SQL Server
App Environ: Windows Desktop
Codebase: .NET Framework
Dev Environ: Visual Studio 200

Standardizes Tech Development, Assessment, & Transition

A TRL-based, Systems Engineering Activity Model that

Assists:



- **Technology Program Definition**
  - Identify **Activities** that will be performed
  - Identify **Documents** that will be produced
  - Provide an Environment for **Tailoring** the M
  - Develop and Employ **"Best Practice" Tool**
- **Technology Transition Management**
  - Technology **Transition**
  - Technology **Transfer**
  - Technology **Marketing**
- **Technology Maturity Assessments**
  - Establishes **Entry/Exit Criteria** - Tailored for each Project
  - Provides a Framework for Performing **Technology Readiness Assessments** (TRA)

"TPMM: A Model for Technology Development and Transition"

TPMM as an Enterprise Level Solution

Mgt Functions / Mgt Level	Technology Program Definition	Technology Maturity Assessment	Technology Transition Management
Tech Manager (Practitioner)	▪ ID activities performed by TRL ▪ ID documents that will be produced /delivered ▪ Develop and employ "Best Practice" Tools	▪ Establishes Technology Readiness Assessment Criteria ▪ Tailored to each program ▪ ID Technology Mgt Risks	▪ Early Customer/USER Involvement ▪ <u>TTA's</u> · Interest · Intent · Commitment ▪ Integration Opportunities ▪ Tech Transfer Opportunities ▪ Align DoD 5000 (Common Language) ▪ Transition Focus – ***Doing The Right Things At The Right Time With The Right People***
Portfolio Manager (Director)	▪ Portfolio Tracking Data	▪ Standardized Measurements ▪ Aligns technologies for cross pollination ▪ ID Program Mgt Risks ▪ Supports Key Decision Points	
Executive Manager	▪ Provides Enterprise Level Program Management Data	▪ Enterprise Assessment ▪ TRLs (Push / Pull) ▪ Funding ▪ Transition ▪ Support s Key Decision Points	

Summary

- TPMM is an ***activity model*** for technology development that is partitioned into phases and gate-qualified using ***TRL's***.
- TPMM is a ***best practice standard*** that expands TRL understanding include ***detailed activities, exit criteria, and deliverables***.
- TPMM is a ***toolset*** used by the Tech Manager to ***plan, guide and measure*** a technology program's development maturity.
- TPMM is an ***alignment mechanism*** that promotes early focus on ***transitioning the technology*** to Acquisition Program Customers.
- TPMM acts as a ***common yardstick*** and provides the criteria to evaluating the ***Technology Development Strategy*** earlier.
- TPMM model provides ***a standard TRL criteria set*** for performing effective ***Technology Readiness Assessments***

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Request a copy of TPMM Version 2 .pdf file at:

http://www.tpmm.info

BACKUP

TPMM Quad Chart
(Notional Tech Program Metrics)

TRL Rating Based on TPMM

- TPMM Phase
- Required Criteria Met/Not-Met
- Gap Analysis (on Un-Met)

Current TRL confidence and Statement of Risk

Technology Development Strategy

- TPMM Requirement? (TRL3 or beyond)
- Status = Draft, Preliminary, Final
- Updated for Current Phase?
- Gap Analysis/Percentage Populated

Programmatic Progress

Transition Management

- Customer/User/Sponsor ID'd
- TTA Version (Interest, Intent, Commitment)
- TTA Matrix Populated
- Signature Status

Transition Planning Progress

TRL Roadmap

- TRL Milestone Schedule to transition
- TPR Status

Program Vision to Transition

Executive Dashboard

Captures the Enterprise View of Technologies in S&T

Status of Programs

- Transition Agreements in place
- Successful Transitions over time
- Program Distribution by
  - TRL
  - Technology Domain
    - Science Discipline
    - Sponsor
  - Acquisition Customer
  - Funding

Facilitate Strategic Planning

- Technologies Distribution
- Technologies Gap Analysis
- Domain Analysis
  - Skill gaps / recruiting needs (Develop/Maintain TC skill set)
  - Diversified Portfolio Analysis
    - Sponsor
    - Science Discipline
- TTA Migration Status

Metrics-driven Executive Dashboard forms the basis of a Decision Support System (DSS)

Identified S&T Technology Management Best Practices

Organization	DAU	DOE Labs	DTRA	NASA	AEDC	SMDTC
S&T Organization Structure	N/A	Ad hoc	Transition Dir (TRIAD)	ATDC Advanced Technology Development Center	Tech Branch	Technology Director
Program Initiation	Technology Development Strategy (TDS)	Ad hoc		Risk Reduction	Request	For Fee - Ad hoc
Program Funding	Program Portfolio			Specific Budget	Venture Funding	Sponsor / Technologies Driver
Needs Analysis	ICD SE		JSTO initiated	NASA Req	Informal	Feasibility Study **[TPMM]**
Transition Management	Technology Transition Agreements (TTA)		Technology Transition Handbook TTAs -1			TTAs -3 [**TPMM]**
Process Enablers	TATM	TRLs	TRLs (+)	TRLs	TRLs	TRL (+) **[TPMM]**

Taken From Study Results performed for Department of Homeland Security S&T